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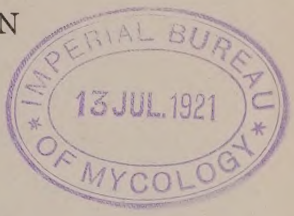

BOTANICAL DEPARTMENT

SOME GINSENG TROUBLES

BY
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EAST LANSING, MICHIGAN
1915

SOME GINSENG TROUBLES.

The results of experiments conducted in Michigan on Ginseng and Golden Seal Diseases

BY ERNST A. BESSEY, PROFESSOR OF BOTANY, MICHIGAN AGRICULTURAL COLLEGE AND J. A. MC CLINTOCK, AGENT, BUREAU OF PLANT INDUSTRY, IN CHARGE OF GINSENG DISEASE INVESTIGATION IN MICHIGAN.

The work reported in this circular was done under a cooperative agreement between the U. S. Department of Agriculture and the Michigan Agricultural Experiment Station. Dr. E. A. Bessey, botanist of the experiment station, had general superivision of the work, but the details were all worked out by the junior author to whom the chief credit for the results belongs. The Michigan State Association of Ginseng Growers materially assisted the work by financing the investigations for the first three months and by constant cooperation throughout the entire course of the work. Many growers have also been called upon for equipment and specimens which they generously furnished. To these the writers take this opportunity to express their sincere thanks.

BLACK ROT OF GINSENG.

Black Rot of ginseng, caused by the fungus *Sclerotinia panacis* Rankin, was first reported by Van Hook* (1) in 1904 from a garden in New York state. He described the habit which the fungus has of attacking the roots during the winter and gave a photograph showing the characteristic appearance of the diseased roots.

Rankin (2) in 1912 studied this fungus more in detail, and it is to him that we are indebted for a description of the life history of this parasite. During the fall or winter, the fungus attacks the roots, turning the outer portion to a jet black color, and changing the inner tissues from a firm to a spongy texture. Sclerotia (hard, black masses of fungus tissue from smaller than the head of a pin to larger than a pea) form over the surface giving a diseased root a very warty appearance. The root remains unchanged thruout the first season, but during the second winter, it turns entirely black and becomes more or less hollow and shrunken. The sclerotia which developed on the diseased roots during the first winter, in some cases produce apothecia (brown salver or trumpet-shaped reproductive structures ½ to 1 inch broad and about as high) during the second winter. The writers have not as yet been successful in finding this fruiting stage, but Rankin (2) found and has figured well developed fruiting bodies of the apothecial type.

* The numbers in parenthesis refer to the bibliography at the close of this section.

The accompanying photographs are typical of various stages in the progress of the disease. (Fig. 1).

The Black Rot fungus is probably spread from root to root chiefly by strands of mycelium (the fine threads making up the vegetative part of the fungus) growing out from diseased roots, but it is possible that it may also be disseminated by spores (the reproductive bodies produced in the apothecia and functioning like seeds).

Altho this is not a common disease in Michigan it has proven rather

Figure 1. Ginseng roots with black rot, first year, showing the sclerotia.

serious at the three gardens where it has been observed, viz. at Coopersville, at Durand and at Cassopolis. In one garden this fungus destroyed over one hundred dollars' worth of ginseng roots during the winter of 1913-1914, and in another garden, it was serious enough so that the grower removed the ginseng from the soil, took down the shading and planted the land to potatoes.

At the rate at which this fungus spreads, it would soon make ginseng growing unprofitable in infected soil, if it was not controlled. The history of a typical case is here given in detail.

Early in the summer of 1913 while visiting a ginseng garden to determine the extent of nematode infection, quite an outbreak of Black Rot was

found. The history of the disease in this garden, as related by the owner is as follows:

About six or seven years previous to 1913, wild ginseng roots, dug from the woods in the upper peninsula of Michigan, were set in one bed in this garden. Two years later when these roots were dug to sell, some of them showed signs of Black Rot, but the disease had not spread very rapidly in the transplanted wild roots. The same fall that the wild roots were dug, the bed was replanted to ginseng seed without any attempt being made to free the soil of the Black Rot fungus. At two years of age, the plants grown from this seed were used to set out beds where the Black Rot first

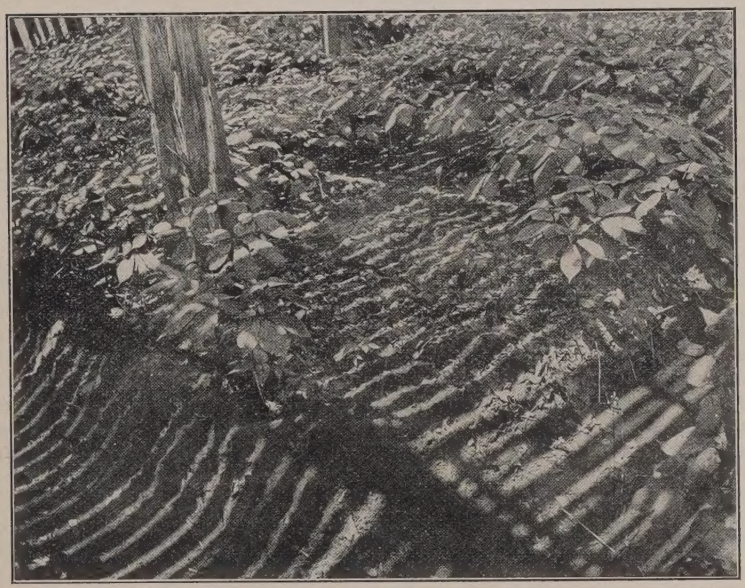

Figure 2. Ginseng bed showing area destroyed by black rot during one winter. This area served as a check plot in the experiments.

showed up seriously in 1912. In the spring of 1912, Black Rot appeared in four-year old plants growing in a bed next to the one from which the diseased wild roots had been dug. This bed of four-year old plants had been grown from seed, so the fungus was not spread to it by transplanting diseased roots. Black Rot also appeared in the spring of 1912 in two other beds of four year old plants which were originally part of the two-year olds grown from seed on the soil from which the diseased wild roots had been dug. No effort was made to control the disease at that time so the fungus continued to spread during the winter of 1912 and 1913 and in the spring of 1913 the three infected areas had each increased from about one-half yard square to about two yards square. (Fig. 2).

In addition to these diseased areas which had held over from 1912, three new centers of the disease showed up in nearby beds. At first

glance these vacant spaces appeared to be due to the roots having been dug, for not a single plant came up within the infected area. On digging into such an area little trouble was had in locating the roots and noting the cause for their failure to come up. Instead of their normal creamy white, they had all turned to a deep black color and bore numerous sclerotia over their surfaces. On digging the plants about the border of an infected area, roots were found in all stages of decay. In this connection it was possible to confirm the statement made by Rankin (2) that infection may occur at almost any point on the root. In some cases the fungus had entered thru the smaller roots and had only partly invaded the main root. Such roots were found only about the borders of diseased areas and many of them had produced well developed tops. Where the fungus had invaded as much as the lower half of a root it caused the top to be decidedly stunted. Where the roots were attacked at the bud no top was produced thus showing that the bud had been completely killed by the fungus.

In the literature on this disease, Van Hook (1) in 1904 suggested as a control measure, the removal from the garden of all infected soil to a depth beyond the deepest diseased roots. Rankin (2) in 1912 suggested the eradication of affected roots and the sterilization of the infected soil with formaldehyde or steam. Whetzel and Rosenbaum (3) in 1912 suggested the removal of affected roots and the sterilization of the infected soil with steam or formalin. As there had been no definite experiments made and recorded up to this time on the control of this disease it was decided that it would be advisable to conduct a definite series of experiments both for the purpose of trying to control the disease and of getting accurate data as to the best methods to apply.

As a check on the various treatments it was decided to leave one plot without any treatment. The plot used as a check was one which had developed during the winter of 1912-1913. In order to keep the fungus from spreading too far the check plot was separated from the rest of the beds in the following manner. A strip of bed nine and one-half feet long and six and one-half feet wide was enclosed in sheet iron set about twelve inches into the soil and extending about the same distance above the surface. Within this enclosure was included the diseased area surrounded by about the same area of healthy plants. To determine whether the disease continued to spread during the summer, a row of stakes was set in the soil at the border of the diseased area. Aside from these two precautionary measures, this infected area was left just as it had shown up in the spring. The plants in this check plot were four years old at the time of their being attacked by the fungus, thus the healthy plants in the plot were on their fifth season's growth.

The bed next to the check plot contained a large infected area which had shown up first in the spring of 1912 and had materially increased in size during the winter of 1912-1913. In the spring of 1913 previous to the writer's visit to this garden, the owner had treated the soil in this plot with 1-80 solution of 40% formaldehyde (1 gal. of 40% formaldehyde to 80 gallons of water) at the rate of about one gallon per square foot of soil. The diseased roots had not been removed from the soil prior to the 1-80 formaldehyde treatment. Altho the writer had not had much experience with this disease, at that time, he was of the opinion that wetting the soil with 1-80 formaldehyde would not kill the fungus in the diseased

roots and especially in the hard black sclerotia. Consequently it was decided to respade the soil and to remove all the diseased roots that could be found before the soil was retreated. Besides the diseased roots, two rows of healthy plants about the border of the plot were dug and removed thus preparing the soil for treatment to a distance of about one foot beyond that which showed signs of the disease. After the diseased roots had been removed, the soil was again turned with a spading fork to thoroughly loosen it. The whole plot, about 85 square feet in extent was then retreated with formaldehyde, using a 1-100 solution at the rate of one gallon per square foot of soil. A row of stakes was then set in the soil about the border of the treated plot.

At the side of this 1-80, 1-100 formaldehyde treated plot was another diseased area which had first shown up in the spring of 1913. The soil in this plot was spaded up and the diseased roots and two rows of healthy plants were removed. The soil was thoroughly loosened with a spading fork, and then the whole plot, about 30 square feet in extent, was treated with 1-100 solution of 40% formaldehyde at the rate of 1 gallon per square foot. The border of the plot was then marked by a row of stakes set in the soil.

Another diseased plot, which first appeared in 1912, but increased during the winter of 1912-1913 to about sixty square feet in area was given exactly the same treatment except that the strength of the formalin solution was 1-50.

Another of the diseased-plots, about twenty-five square feet in area, which appeared in the spring of 1913, was treated like the other plots except that 1-25 formalin was used at the rate of 1 gallon per square foot of soil. The border of this treated area also was marked with a row of stakes.

September 18, 1913, a bed of *five*-year old roots, affected with both Black Rot and Root-Knot nematodes, was spaded up and all of the roots were removed. October 19, 1913 this bed was steam sterilized by Shamel's inverted pan method, using steam at 80 to 100 pounds pressure for thirty minutes. This treatment heated the soil so that potatoes were cooked at six, twelve and eighteen inches below the surface. Sixteen days after this steaming healthy four-year old plants were set into the bed. The bed was examined May 22, 1914 and a perfect stand of plants was found with no signs of trouble so far as could be determined without digging them all up.

October 2, 1913, fifteen healthy four-year old ginseng roots were set in the check plot among the diseased roots, each such healthy root being marked by a stake set in the soil near it. This was done with the idea of determining whether the fungus would spread from the diseased to the healthy roots. During November, 1913, healthy three and four-year old ginseng roots were set out in rows six inches apart in the various formaldehyde treated plots to see if the fungus had been killed out by their respective soil treatments.

As the weather was rather cold and wet in the spring of 1914 the plants were somewhat slow in coming up, and as a result it was impossible to get accurate data until May 22, 1914. On this date the following observations were made:

Of the fifteen healthy plants set in the check plot Oct. 2, 1913, six had failed to come up on account of black rot, and of the nine that did send

up new tops, three were found to be more or less diseased with black rot. From the results one can readily see that it would not pay to set out healthy roots in soil bearing diseased roots. Besides the nine plants which became diseased after being in the diseased area, about forty other plants outside the line of stakes failed to come up and upon digging were found to be diseased, thus showing that the fungus had spread at the borders of the check plot during the winter of 1913-1914.

In the plot which was treated with formaldehyde 1-80 and then retreated with a 1-100 solution, it was observed that about thirty of the 185 roots reset in the treated soil had failed to send up tops and upon digging

Figure 3. Black rot area treated with 1-50 formaldehyde solution and later reset to young plants, showing perfect stand of the latter due to the destruction of the fungus.

these were found to be diseased with Black Rot. This would seem to show that such a formaldehyde treatment could not be depended upon to control the Black Rot fungus.

Of the 80 roots set in the 1-100 formaldehyde treated plot 38 had failed to send up tops and on being dug, these roots were seen to be attacked by the Black Rot fungus. A comparison of the results of this and the previous treatment would seem to show that a treatment with 1-80 formaldehyde plus a retreatment with 1-100 formaldehyde gives better results that the 1-100 formaldehyde treatment alone, but that neither treatment was of any value as a practical control for the Black Rot fungus.

In the plot treated with 1-50 formaldehyde an almost perfect stand of plants came up from the roots set in the treated soil Nov. 5, 1913.

However, a year later quite a number of plants in the plot showed the disease. It must be noted that the soil was very wet when the treatment was made so that it absorbed but little of the formaldehyde solution. Another plot, treated with the same strength (1-50) when the soil was drier showed good control of the disease.

A perfect stand of plants came up from the roots set in the plot treated with a 1-25 solution of 40% formaldehyde thus showing that this treatment was also successful in killing out the fungus in the treated soil.

In two small areas just outside of the stakes, that marked the treated soil of the 1-25 formaldehyde plot, were found a total of twenty-five roots that had failed to produce tops. On digging, these roots were found to be more or less diseased with Black Rot. The disease at these two places probably started from single diseased roots outside the treated area which had failed to attract attention because they were surrounded by healthy plants. The fact that no diseased plants were found in the treated area, even adjacent to these diseased patches, is evidence that the disease did not spread out of the area after treatment.

The soil in the ginseng garden where these experiments were conducted is a clay loam, underlaid with a stiff clay sub-soil. It is impossible to say with certainty that the treatments which were found successful on this type of soil, will be equally successful on other types. In the three places in Michigan where the disease has been found, the soil is rather heavy, so it is probable that the same results could be expected in these places if the treatments were thoroughly made.

In the light of the results obtained, we feel that the following recommendations should be offered for further trial: First, that the soil of a diseased plot be carefully spaded over and all of the diseased roots and at least three or four rows of apparently healthy plants be removed. Second, that the soil be thoroughly loosened to a depth below that to which the diseased roots penetrated. Third, that the soil be sterilized with a solution of formaldehyde made up at the rate of not less than one part of 40 per cent formaldehyde to fifty parts of water, and applied at the rate of at least one gallon per square foot of soil. If the soil contains a large per cent of water at the time the treatment is to be made, it would probably be safer to increase the strength of the formaldehyde solution to one part of 40% formaldehyde to twenty-five parts of water, and then to apply as much of the solution as the soil will take up, but generally, not to exceed one gallon per square foot. In any case, care should be taken that all of the infected soil is thoroughly soaked with the solution. This is best accomplished by having one man fork over the soil, while another man applies the formaldehyde with a sprinkling can.

The Black Rot fungus generally spreads in such an irregular way that it leaves a plot of soil which is not of a size or shape suitable for steam sterilization, but if in any case the diseased areas are suitable for such treatment and the equipment is available, the steam sterilization of the infected soil by the inverted pan method would be preferable because it leaves the soil in better physical condition than does the formaldehyde treatment.

SUMMARY.

Black Rot of ginseng was first reported by Van Hook from a garden in New York state. The life history of the causal organism was worked out by Rankin who named it *Sclerotinia panacis.*

The fungus attacks the roots during the winter, and does not spread at all during the growing season. During the first winter only the outer part of the diseased root is turned black, but the inner part is changed to a white spongy texture. During the second winter the infected roots turn black thruout and often become more or less hollow and shrunken.

The black sclerotia which are developed over the surface of the roots during the first winter, may send up apothecia during the second winter. The fungus is probably chiefly spread by mycelial strands running thru the soil, and possibly also by spores. So far, the disease has been found in but three places in Michigan, but has caused considerable loss in these gardens.

Soil sterilization with a 1-100 or a 1-80 solution of 40% formaldehyde used at the rate of one gallon per square foot of soil failed to control this fungus. Similar sterilization with a 1-50 or a 1-25 solution of 40% formaldehyde applied at the rate of one gallon per square foot, was successful in controlling the Black Rot fungus.

Sterilization with steam, using the inverted pan method, resulted in killing out the fungus and in leaving the soil in better physical condition.

ACKNOWLEDGMENTS.

The writers are greatly indebted to Mr. B. G. Horling of Coopersville, Michigan, in whose garden these experiments were conducted for his very able assistance thruout the course of the experiments.

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FORMALDEHYDE TREATMENT OF THE SOIL

FOR THE

CONTROL OF DAMPING-OFF OF GINSENG SEEDLINGS.

Under favorable conditions for their development, damping-off fungi cause one of the most serious troubles with which the ginseng grower has to contend, viz., the damping-off of young plants in the seedling beds. With the tender seedling plants standing very thickly in the beds, and the soil shaded with a lattice roof which tends to increase the humidity of the surrounding air, the damping-off fungi have more than an average chance for rapid and vigorous development and as a result, they may destroy large areas of seedlings in a very short time.

It is a pretty well established fact among ginseng growers that, in

order to produce a good top next year, a ginseng seedling must produce a well developed bud during the present season. When damping-off fungi attack the ginseng seedlings early in the summer and destroy the tops before the bud has formed it results in no top the next season, and in many cases, no permanent root is produced either. If this occurs over large area of seed bed, the results are disastrous to the grower, for if he cannot produce good seedlings, he can hardly expect to grow a profitable crop of roots suitable for marketing as dry roots.

During the spring of 1913 damping-off of ginseng seedlings became quite serious at one of the gardens where nematode control experiments were being conducted. As the junior author was not then aware of any treatments which had proven successful in the control of damping-off in ginseng seedlings, it was thought advisable to try certain chemicals known to be detrimental to fungi.*

As a check on the treatments to be used, diseased spots in various beds were selected and marked about the borders by scattering hydrated lime on the soil to show the extent of the disease at that time.

Of the remaining infected spots about half were treated with formaldehyde one to fifty (one part of 40% formaldehyde to fifty parts of water) applied at a rate so as to thoroughly wet the soil to a depth of about two inches. The other spots were treated in a similar way, except that a one to one hundred formaldehyde solution was used instead of a one to fifty solution. The borders of all these treated plots were marked with hydrated lime scattered on the soil.

Within the next few days, the results of the treatment became very evident when contrasted with the check plots. The plants continued to damp-off beyond the limed mark in the check plots thus showing that the fungi had not stopped spreading of their own accord. In contrast to the plants about the check plots, the plants surrounding the treated plots with few exceptions remained standing thus showing that the damping-off fungi were not active in the formaldehyde treated soil.

In the light of the results obtained by these treatments, it is suggested that a 1-100 solution of 40% formaldehyde be used wherever it will give the desired results, but that the strength of the solution be increased to 1-50 if the 1-100 solution should fail to immediately stop the spread of the damping-off fungi.

THE GINSENG NEMATODE AND ITS RELATION TO GOLDEN SEAL.

When ginseng was first brought under cultivation, it was heralded as a plant free from diseases, but all too soon for the unsuspecting beginner in the business, it was found to be subject to a variety of diseases. One of the most serious of these was the root-knot caused by the parasitic root-knot nematode, *Heterodera radicicola*. (Fig 4). It is only within recent years that the majority of ginseng growers have become informed as to

*Since then his attention has been called to an article in which essentially the method recommended here was reported in Special Crops, Sept. 1912.

the true nature of root-knot; therefore, it is not surprising that some of the pioneers in ginseng culture mistook the nematode root-knots for a beneficial growth like the nodules on the roots of legumes. With this idea in mind, some of the early growers carefully protected and cultivated the ginseng roots with root-knots on them, in the hope of obtaining a strain which would be better than the average.

It was during this period of ignorance relative to the true cause of the

Figure 4. Root-knot on Ginseng.

root-knot that the disease was widely spread by shipment from place to place of diseased roots intended for starting new gardens.

As the habits of the ginseng plant became better known, the growers observed that the roots with knots grew much more slowly than those without knots. They were forced to the conclusion that whatever the cause of the knots, the condition was not beneficial to the growth of the ginseng plants, but instead caused such stunting that often five yeear old plants were no larger than healthy two year olds.

When the nature of the root-knot and its seriousness was finally made plain, the growers found themselves in a sad predicament. Their gardens,

representing a large investment for plants, shading, etc., were either not producing an income or at least one not at all proportional to the capital invested.

When ginseng could no longer be grown at a substantial profit the growers naturally began to look about for some other crop which could be grown under the same conditions.

Next to ginseng the golden seal was the most profitable plant they had learned to produce. Ginseng and golden seal have been more or less companion crops in Michigan for a considerable time. As both are shade plants with cultural characters somewhat similar, it was but natural that they should be brought together in the same garden by many growers. In a few cases growers have planted both ginseng and golden seal in the same bed, but the majority of growers plant solid beds of either ginseng or golden seal. The latter method is by far the best from a cultural point of view, because the type of roots of these two plants is very different.

Casual observation seemed to show that golden seal grew fairly well in soil where ginseng failed to produce a profitable crop. Therefore, it was thought that golden seal was not attacked by nematodes. No doubt this oversight on the part of the growers was due to the fact that the fibrous branching root system of the golden seal plant is such that the root-knots are not so conspicuous as on ginseng roots and were, therefore, overlooked.

As ginseng at its best is a more profitable crop than golden seal, due to its higher price per pound and larger number of pounds per acre, most of the growers who changed from ginseng to golden seal, hoped to get back to the growing of ginseng again, as soon as their soil had been freed from nematodes.

It had already been proven, (Bessey, 1911) that a rotation consisting of resistant crops, greatly reduced the number of nematodes in fields which were badly infested at the beginning of the rotation. That is, if crops of various resistant plants were grown for two or three years on fields which had become badly infested, the nematodes gradually died out and left the soil in condition to produce profitable crops of susceptible plants for a few years.

As it took about three years to grow a crop of golden seal, it was thought that one such crop would free the soil of nematodes and leave it in condition to produce again a profitable yield of ginseng. Many of the older growers stated positively that golden seal was not attacked by nematodes. Hence, this method was frequently discussed at growers' conventions and was a common practice at the time the junior author took up the work on ginseng diseases in the spring of 1913.

Since this method might be an important factor in the control of the ginseng nematode, it was thought best to give golden seal a good trial under carefully planned experimental conditions. As the experiments were to be conducted in Michigan, the use of Michigan grown golden seal would have been preferable but it was impossible to get sufficient Michigan grown roots at the time the experiments were started. The season was already well advanced so the use of roots from other sources was necessary, in order that some data might be obtained. Thru the efforts of Mr. L. J. Brown, Secretary of the Michigan State Association of Ginseng Growers, one hundred golden seal plants were obtained from a grower in Tennessee.

June 1, 1913, these plants were set in rows between rows of ginseng in

a bed badly infested with root-knot nematodes. In September, 1913, all of the golden seal plants were dug from the bed and carefully washed free from soil. The majority of the plants had made a better root growth than one would have thought from looking at the tops before digging. These new roots were far from being normal, however, for they were so badly attacked by nematodes that they were little more than a mass of root-knots. It is possible that this excessive root growth may have resulted from the attacks of the nematodes, for it is known that other plants often throw out a large mass of roots in an effort to overcome the ill effects of the parasite. As new roots grow out they are in turn attacked by the nematodes with the result that the plant generally fails to make thrifty growth. This appeared to be the case with the golden seal plants for even with their large root system they had produced rather stunted tops. From the appearance of the golden seal roots, it was evident that the knots were produced by nematodes, but in order to prove this point, a large number of the root-knots were dissected and nematodes in all stages of development were found in them. (Fig. 5).

Figure 5. Root-knot on Golden Seal.

The result of this experiment was such as to justify the conclusion that golden seal is not always immune to the root-knot nematode. The experiment also added southern grown golden seal to the long list of plants attacked by this nematode. These observations were so different from those reported by ginseng growers up to this time, that it was believed the use of southern grown plants might have had something to do with the results obtained.*

The evidence being in this uncertain state, no recommendations could be made until more data were collected.

In October, 1913, the junior author received from Mr. B. G. Horling of Coopersville, Michigan, some Michigan grown golden seal roots. These had been grown thruout the summer in a nematode-infested ginseng bed. The roots had suspicious looking knots upon them and by dissection under the microscope, these were found to be infested with the root-knot nematode. To the writer's knowledge this is the first record of this parasitic nematode attacking Michigan grown golden seal, and to Mr. Horling is due the credit of finding the specimens. A little later on in the season, Mr. John

*A preliminary note on these observations was published in Phytopathology (McClintock, 1914) to acquaint pathologists thruout the country with this important discovery.

L. Ferris of Plainwell, Michigan sent specimens of Michigan golden seal whose roots were covered with the largest knots yet seen on golden seal. These knots also on dissection, proved to be infested with the pest.

These two records from two such widely separated points in the State, along with the observation on southern grown roots in the experiments reported, justify the conclusion that golden seal, no matter where grown, is susceptible to the attack of the root-knot nematode. It is, therefore, safe to say that golden seal cannot be depended upon to starve out the root-knot nematode in infested ginseng beds. At present it cannot be said definitely whether the nematodes will injure golden seal to the extent of making it an unprofitable crop to grow in infested soil, but this condition seems likely.

During the fall of 1913, experiments were started in two ginseng gardens in Michigan, for the purpose of collecting data relative to the effect of root-knot nematodes on the growth of golden seal plants; the results of these experiments cannot be obtained until the golden seal has grown in the infested soil for a year or more. A comparison then of unaffected and diseased plants will, no doubt, decide the question.

Since golden seal cannot be depended upon to starve out the root-knot nematodes, the question naturally arises as to what will free the soil of this pest. Experiments are under way to test other drug plants for resistance to the parasite, but the data on these will not be available for a couple of years. For a year, the junior author has been working on various chemical treatments of the soil, aiming at the eradication of the root-knot nematode. Up to the present time, no treatment has been found that can be depended upon to give complete satisfaction. Accordingly no treatment is at present recommended.

The only practical solution of the nematode problem known at the present time, with such intensive crops as ginseng, golden seal and greenhouse plants, is steam sterilization of the infested soil by the inverted pan method. This treatment costs about $10 per thousand square feet of soil. For full details as to the method, the reader is referred to the work of Bessey (1911) and Whetzel and Rosenbaum (1912). It is hoped to be able to publish complete data as to steam sterilization of ginseng beds at a future date.

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